Florida

Intelligent Transportation Systems Benefits

Prepared for

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List of Acronyms

ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CAD	Computer-Aided Dispatch
CCTV	Closed-Circuit Television
CVISN	Commercial Vehicle Information System Network
CVO	Commercial Vehicle Operations
DOT	Department of Transportation
E-911	Enhanced 911
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IMS	Incident Management System
ITS	Intelligent Transportation System
JPO	Joint Program Office
MSA	Metropolitan Statistical Area
USDOT	United States Department of Transportation
VMS	Variable Message Sign
WAN	Wide-Area Network
WIM	Weigh-in-Motion

1. Introduction

The Florida Department of Transportation (FDOT) has developed an intelligent transportation systems (ITS) program called SunGuide^{SM} that will assist in the deployment of transportation solutions. The investment in an ITS Program requires justification and resulting benefits. Departments of transportation (DOTs) throughout the United States are working on determining what the best measures are to show system improvements in effectiveness and safety as a result of ITS applications. This white paper will outline some of the benefits realized across the country and highlight potential Florida ITS benefits.

1.1 ITS National Program Overview

The national ITS program was tasked by Congress to provide feedback in the form of benefits from the investment in transportation systems technology. The United States Department of Transportation's (USDOT) Joint Program Office (JPO) is responsible for collecting data across the United States on ITS implementations. In order to identify specific types of projects and pinpoint detailed data on program areas, benefits were classified in the two following categories. The benefits area's category describes the type of classification and the overall benefits category gives a general list of benefits expected to occur at some level in the specific areas.

1.1.1 ITS Benefit Areas

- **Metropolitan Areas** – There is no specific population number that signifies a metropolitan area, however, this is more generally defined as a higher-density community with recurring congestion and major transportation infrastructure investments.

- **Rural Areas** – These are the smaller communities throughout the state that may have interstates traversing their largely collector and locally-classified roadways. Rural areas are identified as areas with non-recurrent congestion and remote roadways.

- **Commercial Trucking** – This benefit area encompasses the commercial vehicle operations (CVO) and Commercial Vehicle Information System Networks (CVISN) ITS categories. The movement of goods and services via the motor carrier industry will be measured in this benefit area.

- **Intelligent Vehicle Systems** – These systems include in-vehicle and roadside-to-vehicle types of projects that enable "smart" vehicle operations. Any automated activities associated with the vehicle itself will be measured in this benefit area category.

1.1.2 ITS Overall Benefits

The national ITS program has developed a short list of benefits that all ITS federally funded projects are measured by. Some benefits are more applicable than others depending on the particular deployment. For instance, in the rural areas of the United States, reduced congestion may not be as appropriate a measure as in the urban setting. The following is a list of the general overall benefits ITS projects are expected to achieve:

- Enhanced public safety;
- Reduced congestion;
- Improved access to travel and transit information;
- Cost savings to motor carriers, transit operators, toll authorities and government agencies; and
- Reduced environmental impacts.

1.2 Florida ITS Program

Florida is implementing ITS services in statewide, regional, and local areas, working with various departments, agencies, and jurisdictions. ITS efforts are on-going in Tallahassee, with multi-agency initiatives occurring at the regional and national levels. Florida has an ITS Florida chapter, a state affiliate to ITS America. FDOT is a member in good standing of ITS America and participates in national ITS initiatives, including CVISN.

Some of the locations throughout Florida where ITS projects are being implemented include the following:

- Sarasota-Bradenton metropolitan statistical area (MSA) (Sarasota and Manatee counties);
- Tampa-St. Petersburg-Clearwater MSA (Hernando, Pasco, Pinellas, and Hillsborough counties);
- Lakeland-Winter Haven MSA (Polk County);
- Orlando MSA (Lake, Orange, Osceola and Seminole counties);
- Daytona Beach MSA (Flagler and Volusia counties); and
- Melbourne-Titusville-Palm Bay MSA (Brevard County).

One example of a coordinated ITS effort is the Tampa Bay SunGuide^{SM} ATIS initiatives.

2. Reported Benefits

FDOT ITS initiatives can generally be defined as falling into the following high-level categories for benefits evaluations:

- Advanced transportation management systems (ATMS);
- ATIS; and
- CVO.

These benefit areas will be reviewed for results in other areas across the United States to determine the types of benefits other jurisdictions are experiencing and to obtain a sense of what measurements are important to other DOTs.

2.1 Advanced Transportation Management Systems (ATMS)

2.1.1 Incident Management Systems (IMS)

Florida is planning on implementing the systems that fall into the IMS category. These projects include, but are not limited to:

- Regional evacuation coordination; and
- Enhanced 911 (E-911).

Components of the above-referenced projects will include significant regional multi-agency cooperation and a communications system that can transmit voice and data among agencies for efficient resolution of incidents.

Some of the benefits that are expected to result from the implementation of IMS include:

- Smoother, more efficient response and clearance;
- Reduced identification and response time;
- Decreased frequency of incidents; and
- Reduced fatalities.

Benefit results that other jurisdictions have experienced in incident detection and verification include the information indicated below. Note that some jurisdictions quantify benefits in terms of benefit to cost ratios, while others choose to correlate benefits in direct transportation terms (i.e., reduced congestion by a certain amount).

Incident Detection/Verification

- San Diego, California – Using smart call boxes to control incident detection field devices could save $7,365 to $80,700 in capital costs;

- Maryland – expected benefit to cost ratio of 10:1;
- Antwerp, Belgium – benefit from vehicle hours saved of $98,000 in United States currency per year; and
- Maryland, CHART – Benefit to cost ratio of 5.6:1 with most of the benefits resulting from a five percent decrease in delay associated with non-recurrent congestion.

Incident Response/Management

- Houston, Texas – annual delay savings of 572,095 vehicle-hours with an economic value of $8.4 million;
- Denver, Colorado – reduced cost of delay by $0.8 to $1.0 million for the morning period and $0.9 to $0.95 million for the evening (assumes time value of $10 per hour). Including program costs for tow truck operators, the benefit to cost ratio ranged from 10.5:1 to 16.9:1;
- San Antonio, Texas – average delay savings of 700 vehicle-hours and a resulting fuel consumption reduction of 9,800 liters for a major incident, with an annual cost savings of $1.65 million;
- Minneapolis/St. Paul, Minnesota - benefits through reduced delay totaled $1.4 million for a program that costs only $600,000 to operate; benefit to cost ratio of 2.3:1;
- Charlotte, North Carolina – benefit to cost ratio of 7.6:1 for an initial start-up cost of $2.85 million;
- Chicago, Illinois – benefit to cost ratio of 17:1 with an annual program cost (1990-93) of $3.5 million in operating costs and $5.5 million in overhead costs;
- San Francisco, California – benefit to cost ratio of 3.3:1 for annual cost of $295,500;
- San Francisco, California – cost savings for delay of $420 per breakdown (assuming $10/hour of delay and 42 vehicle-hours delay savings);
- San Francisco, California – cost savings for delay of $200 per accident (assuming $10/hour of delay and 20 vehicle-hours delay savings);
- San Francisco, California – cost savings for fuel consumption of $35.65 per breakdown (assuming $1.15 per gallon and 31 gallons fuel savings);
- Houston, Texas – benefit to cost ratio of 19:1 for a operating costs of $196,500; benefits to assisted motorists estimated at $125,000; benefits to other motorists in terms of delay was estimated at $3.6 million (assuming $10.47, 1992 value of time);
- Los Angeles, California – benefit to cost ratio range of 12:1 to 15:1 for an annual estimated cost of $9 million (1992); and
- Ontario, Canada – benefit to cost ratio range of 2:1 to 30:1.

2.2 Advanced Traveler Information Systems (ATIS)

Florida is planning on implementing the systems that fall into the ATIS category. These projects include, but are not limited to:

- ATIS and data collection; and
- Central data warehousing.

Components of an ATIS can include in-field detection devices, databases for data storage and retrieval, and hardware and software configurations.

ATIS benefits include:

- Historic data to base decisions on;
- Regional data, not just FDOT; and
- Ability to see trends, hot-spots, and correct problem areas.

ATIS benefit data contains different results that can be "traditionally" measured in ATMS or CVO operations. Much of the ATIS benefits are results from surveys indicating how much travelers are willing to pay, what types of data they are looking to obtain (i.e., road closures, detours, estimated delay times, alternate routes, parking garage availability), by what means of communications media are they wanting the information to be disseminated (i.e., television, cable, radio, fax, and wireless applications such as cell phones and palm pilots), in what manner they want the information formatted (i.e., customized route data, regional data, or specific metro data) and other preferential-related traveler information benefits data.

Some of the benefits that are expected to occur as part of a traveler information ITS project include:

- Minnesota, Travlink [automatic vehicle location (AVL), computer-aided dispatch (CAD), automatic vehicle identification (AVI), on-line, kiosks, electronic signs, and display monitors] – Fifty-seven percent agreed or strongly agreed that information was accurate and reliable; 34 percent were neutral;

- Washington, D.C. – A survey regarding traveler information indicates that 79.6 percent believe they save time, 37.9 percent save money, 87.4 percent avoid traffic problems, and 61.1percent relieve anxiety or frustration;

- Washington, D.C. – Sixth-tenths percent (0.6%) of those surveyed reported using radio, television, and the internet for getting travel information;

- Washington, D.C. – Three-tenths percent (0.3%) of those surveyed reported using television and the internet for getting travel information; and

- Washington, D.C., SmarTraveler (phone and web) – Eleven percent of the sample indicated awareness of the information service; ten percent use phone service and six percent use Web page.

2.3 Commercial Vehicle Operations

Florida is planning on implementing the systems that fall into the CVO category. One such project includes the Virtual Weigh Station Pilot.

Components of the CVO system include weigh-in-motion (WIM) scales. These can be mainline highspeed scales or low speed scales that are placed on ramps or rural roadways. Other CVO system components encompass the communications system and wide-area network (WAN) of computers for transfer of information to main databases.

Some of the benefits that are expected to occur as part of a commercial vehicle ITS project include:

- Reduced oversize/overweight violations;
- Enhanced inspection capabilities;
- Enhanced enforcement; and
- Improved resource utilization.

Some reported results of CVO benefits include the following:

<u>Electronic Screening Projects</u>

- Benefit to cost ratio ranges from 6.5:1 to 1.9:1;
- Colorado – WIM and AVI estimates a benefit to cost ratio of 7:1; and
- Detroit/Windsor – Identification and toll collection at border crossing expect a benefit to cost ratio of 4:1 for commercial vehicles due to reduced delay.

<u>WIM Installations</u>

- Colorado – WIM and AVI estimates a benefit to cost ratio of 7:1; and
- HELP – Operating cost savings of up to $169,000.

Commercial vehicles also benefit from general ATMS improvements as well, with energy and fuel savings from coordinated signal systems, ramp metering, or other traffic operations center management techniques that keep the general flow of the traffic moving through the metropolitan areas. CVO also benefits from ATIS applications through the reception of advanced traveler information indicating congested areas, incident reporting, and road closure data.

2.4 Tangible Benefits

The national ITS program focuses on specific areas of benefit measurement. These areas are:

- Safety;
- Environmental;
- Mobility; and
- Finance.

Within these areas of benefit evaluation, ITS projects may expect to yield the following types of results:

- Reduced number of incidents;
- Reduced congestion and delay;
- Provides motorists with choices through increased information;
- Increased speeds through toll plazas;
- Saves lives through emergency response; and
- Helps transit work better (on-time performance).

2.5 Intangible Benefits

A significant amount of planning and strategic analysis needs to go into the development of benefits. Funding should be set aside for project evaluations so that benefit results can be measured and reported. The result of a well thought out benefits evaluation process will pay in intangible, invaluable returns that may include the following.

- Increased positive public perception of the FDOT; and
- Enhanced perception of safety and technology.

ITS is good public relations. Remarkably, the public does not see day-to-day operations or understand the purpose of all the behind-the-scenes data collection. However, what the public does see is roving freeway service patrols, variable message signs (VMS), and efficiently managed incidents. What FDOT does with the ITS components that are “on the front lines” and most visible to the motoring public will be critical to how the rest of their operations is perceived.

3. Lessons Learned

There are significant issues regarding the measuring of benefits, questions involving which benefits have the most value and how they should be measured, and lessons to be learned from previous experiences. Here are some general lessons learned followed by issues that many DOTs are resolving as part of their ITS implementations and benefit evaluations:

- Complete regional and statewide architectures that serve as guides;
- Implement national standards;
- Includes the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) as partners;
- Pool resources with local jurisdictions;
- Become an active ITSA member. This promotes the program and gets your state noticed;
- Educate political leaders; and
- Select the “right” measures that will “speak to your legislatures”.

3.1 Program-Wide Issues

The development, implementation, and evaluation of a new way of doing business, ITS – investing in technology, does not come without challenges. Cross-cutting issues that have been noted across the country include:

- Funding;
- Potholes versus technology;
- Construction versus operations and maintenance;
- Change in institutional philosophies and methodologies;
- Resources (time, trained staff); and
- Coordinated/Cooperative multi-jurisdictional agreements.

More than any other issue, the institutional changes that are undergoing change as a result of ITS implementation are the most challenging. In order to implement ITS on a regional basis, new relationships are forming between DOTs, among local transportation agencies, with metropolitan planning organizations (MPOs), and the general public. More public/public, public/private, and private/private partnerships are emerging. More consensus-building, consortia-forming, and strategic alliances are forming now than ever before to take advantage of opportunities and streamline business processes. Regional DOT forums are sharing data across state lines; pooled-fund studies are testing technologies before deployment in partner states; and regional procurement strategies are taking advantage of economies of scale gained from the states, counties, cities and other local transportation agencies buying the same types of controllers, VMS, closed-circuit televisions (CCTVs) and other components. Not only are DOTs saving money on negotiating large procurements, they are also ensuring that systems can talk across boundaries. This first generation of DOT professionals have learned a new way of conducting business, through the advent of ITS, and it has been a challenging road to traverse.

The development of an evaluation plan to measure transportation system benefits is just the first step towards justifying public tax dollar investments. Having a strategic approach to ITS deployments, getting the "right" projects implemented first that will be "early winners" and demonstrate that further investment is warranted is every transportation professional's challenge. The general consensuses in the transportation industry are included in the following sentiments:

- It pays to invest in technology;
- ITS is working smarter, not harder;
- There is no "silver bullet" – it's a conglomerate of solutions; and
- Pooled-resources are the wave of the future.

ITS implementation is requiring that DOTs change the way they do business in every sense, internally and externally. It is also requiring greater accountability for transportation system performance. At the national and local levels, political officials are getting increasingly involved with transportation system policies and DOT decision-makers are coming under greater scrutiny for their approaches to solving an increasingly complex issue – transportation system management. The utilization of quality measures and the evaluation of projects for benefits provided will assist DOTs in continuing to do their job, which is to keep the public moving.

4. Recommended Benefits for the FIHS Limited-Access Corridors

To determine the effectiveness of the proposed ITS for the FIHS facilities, the following benefits were identified from studies around the country and were determined to be applicable to the Florida intrastate system:

- A five percent decrease in delay is anticipated as a result of IMS based on data provided by the Maryland CHART Program.

- A 15 percent reduction in injury-related accidents and fatalities is anticipated as a result of freeway management services based on data from the FHWA Fatal Accident Reporting System experience in San Antonio, Texas.

- A 35 percent reduction in property-damage only accidents is anticipated as a result of freeway management services based on data from the FHWA Fatal Accident Reporting System experience in San Antonio, Texas.

- A 7:1 benefit to cost ratio is anticipated for the sum of CVO that will be deployed in FDOT's CVISN program and the virtual weigh station proposed for I-4 in the Tampa area based on the experiences of the Colorado Department of Transportation.

- Benefits associated with ATIS include reductions in travel time and operating costs. Additional benefits are anticipated from congestion avoidance and improvement in the quality of driver convenience. Since no quantitative data was available to support an estimate of these benefits from other areas, a generally accepted benefit to cost ratio of 1.5:1 was used to estimate these benefits.

- Benefits associated with smart work zones are anticipated to include reductions in travel time and operating costs, reductions of accident rates and the severity of accident rates in work zones, and improvement in the quality of driver information. Since no quantitative data was available to support an estimate of these benefits from other areas, a conservative benefit to cost ratio of 1:1 was used to estimate these benefits.

These generalized benefits will result in significant savings in time and operating expenses for travelers and commercial vehicles operating on the FIHS. A quantitative assessment of these benefits in relation to the costs of deploying these systems will be made as part of the implementation plans for these corridors.

In addition to these assumptions regarding the benefits of ITS in Florida based on other studies, before and after studies are recommended for implementation. These studies should be performed for a range of ITS deployments and continuous monitoring is recommended to support development of a statewide ITS program. These studies will confirm, support, validate, and demonstrate the benefits derived from ITS deployments.

In addition to benefits derived from savings in travel times through congestion reduction, the benefits analysis should also seek to document the improvements in customer service, travel time reliability, and predictability of travel times. Nationally, research in these areas is beginning and can be used as a model for investigation in Florida.

5. Benefits Methodology

5.1 Introduction

The most appropriate method for measuring the benefits of ITS deployments is to use a life-cycle cost analysis (LCCA). This analysis will compare the costs that are required to build, operate, and maintain ITS deployments with the anticipated deployment benefits. There are three major areas of ITS benefits that will be evaluated. They are as follows:

- Incident/Freeway Management Systems (IMS/FMS);
- Advanced Traveler Information Systems (ATIS); and
- Commercial Vehicle Operations (CVO) and Commercial Vehicle Information Systems Networks (CVISN)

The following sections will define the LCCA and illustrate the methods involved with the LCCA.

5.2 Principles of Analysis

LCCA consists of identifying the significant costs associated with each alternative, adding each type of cost (user and ownership) by year, discounting them back to a common base year, selecting the alternative, and tempering the final selection with non-economic considerations. There are two basic types of analysis that are usually performed for any project. The first is a comparison of alternatives to identify the optimal solution in terms of economic factors. The second type of analysis is the determination of overall project feasibility. All projects require this analysis of feasibility. When determining the overall feasibility of a project, the analyst must consider a "no action" alternative where the project objectives are abandoned and the existing conditions are allowed to continue. These two analyses are usually performed concurrently through the inclusion of a "no action" alternative in the alternative analysis.

LCCA is a relatively simple technical analysis; however, the following principles were to be followed:

- Be objective in the analysis. The purpose of the analysis is to apply a common basis for determining the feasibility of a project or comparing alternatives. Although professional judgment is required in performing the analysis, personal judgment should not be used to bias the results of analysis.

- The analysis is a study of the future and, as a result, uncertainty will exist in any estimate of project costs or benefits. Therefore, ranges of values should be tested for alternatives that are questionable in their justification (i.e., benefit to cost ratio near 1.0) or if the project requirements, usage, or other design factors are not clearly understood.

- All past investments are irrelevant in the analysis. All past investments are considered "sunk," or lost costs, in the analysis.

- All analysis should use a common period. Cash flow diagrams and other methods are available to assist the analyst in determining an appropriate analysis period. Analysis periods should not extend beyond the ability to forecast variable reliability. Where elements of the analysis have much longer lives than the typical project element lives (i.e., land, which has an infinite life), funds-flow factors should be used. The minimum period that should be considered in the design life of a facility is typically 20 years. For elements of FIHS, longer periods should be considered to reflect the importance of this system. A minimum of 30 years is recommended for FIHS facilities. However, as the design life of ITS projects is limited by the anticipated life expectancy of the ITS devices, a ten-year analysis period should be used.

- The differences in alternatives should control decision-making. If two alternatives use the same basis for comparison, the differences between the alternatives are significant. Therefore, the inputs used in LCCA should be normalized when comparing alternatives within a project. Alternatives should be compared with each other and not simply to the "no action" alternative to select the "optimal" solution.

- The final decision in any analysis may not be based on the result of LCCA, but rather on other factors. There are situations where less than optimal solutions in terms of LCCA are also rational. These solutions are usually arrived at through the public policy process, which is the accepted mechanism for the resolution of conflicting values and goals in our society. Elected decision-makers attempt to arrive at solutions that are the most acceptable to the greatest number of people. An example of such a conflict is the need to ensure an equitable distribution of benefits by providing access to the transportation disadvantaged. It is normally impossible for the analyst to account for these conflicting values in the monetary terms that are input in the analysis process.

5.3 Economic Costs and Benefits

Transportation infrastructure in its most basic form is a public good that is used as a factor of production. All of the benefits for constructing a road or any other transportation facility are derived from its use as a mode of transportation. Transportation investments should lower transportation costs sufficiently to cover the full costs in the execution of the plan or program, including capital, future maintenance, and operating costs. The benefits from a transportation project may be realized in reduced user costs resulting from reduced ownership costs, travel time savings, reduced vehicle operating costs, and reduced accident costs. Additional costs that are associated with transportation improvements such as reduced depreciation on a vehicle and reduced air or noise pollution, are difficult to quantify for any specific project. For example, the economic benefits from transportation infrastructure investment can be determined indirectly through increases in real wealth. Most analyses, however, will focus on the benefits that are derived through reductions in transportation costs only.

The benefits of lower transportation costs are passed on to consumers in the form of lower prices for goods or services, to workers in the form of increased wages, to land owners in the form of increased value, and to owners of business in terms of increased productivity and profit.

The project travel characteristics that describe the amount of travel that occurs within a project's area of influence is an important input to the LCCA procedure. The data that is required includes daily vehicle-miles traveled (VMT), daily truck-miles traveled (TMT), daily average speed, free-flow speed, and the number of fatal accidents, accidents with injuries, and accidents with property damage only. These values were collected from FDOT's Mobility Performance Measures (MPM) Database. All statistics are for the year 1999.

5.4 User Unit Costs

5.4.1 Value of Travel Time

The value of travel time is a function of the trip purpose and the traveler's wage rate. For the most sophisticated analyses, a breakdown of vehicle trip purpose, trip length, occupancy, and type is recommended.

5.4.2 Vehicles

The value of travel time assigned to automobiles should account for the trip purpose and occupancy of the vehicles. When less sophisticated analyses is required, the minimum wage rate of $5.25 (2001 dollars) can be used for the driver. The value of travel time for passengers is estimated to be one-third the wage rate for work or commuting trips and one-sixth the wage rate for non-work related trips. Average occupancy and trip purpose data is available from the area's travel demand forecasting model prepared using the Florida Standard Urban Transportation Modeling Structure (FSUTMS). Average vehicle occupancy for passenger vehicles in Florida is estimated to be 1.2 persons per vehicle. Also, for the purpose of this analysis, the value of travel time for passengers will be one-half the wage rate for all trips regardless of trip purpose. Thus, the average passenger vehicle hourly cost is estimated to be:

1(driver) * $5.25 + .2 (passengers) * ($5.25/2) = $5.78 per hour

The value of travel time for commercial vehicles is much greater than that of passenger cars. It must account for both the hourly wage of the driver and the cost of vehicle operation. The hourly cost of commercial vehicles is estimated to be $60 dollars per hour.

5.4.3 Accident Costs

Human factors are the single largest contributors to accidents. This makes accident reduction difficult to estimate. While accident reduction is an economic benefit, there are many improvements that cannot affect accident rates in the long run. Measuring economic benefits of accident reduction involves estimating the probable reduction in accidents by severity type. Accident rates are usually expressed in accidents per million VMT. Severity is classified by the following: property damage only, injury, or fatal accidents. The estimated costs of accidents by severity for use in LCCA are as follows:

- Fatalities are estimated at $1,000,000;
- Injuries are estimated at $25,000; and
- Property damage only is estimated at $2,500.

5.5 Project Owner Costs

5.5.1 Engineering and Contingencies

The cost of engineering and contingencies should be included in any estimate of the project costs. When other estimates are not available, 15 percent of the construction costs may be used to estimate the costs for preliminary engineering, design, and other contingencies.

5.6 Construction Costs

The estimated construction costs to be used in the LCCA of ITS projects include all material, hardware, and labor costs involved in the implementation of the project.

5.7 Maintenance Costs

The estimated operations and maintenance (O&M) costs to be used in the LCCA of ITS projects are based on the type and number of devices per year. The operating and maintenance costs should be calculated for the life cycle of the project (ten years).

5.8 Construction, Engineering, and Inspection (CEI) Costs

CEI costs must be calculated for each project. This cost is simply estimated to be twenty percent of the cost for construction of the ITS project.

5.9 Project Travel Characteristics

5.9.1 Economic Factors – Discount Rate, Cost of Capital, and Inflation

For most transportation project LCCAs, a discount factor should be used that reflects the time value of money, the scarcity of funds, and the value and risk of alternative uses. The Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) adopted a discount factor of seven percent to be used in the analysis of transportation projects involving alternate modes (i.e., OMB Circular A-94 that promotes the uniform use of discount rates in the analysis of government projects and programs). If sensitivity analysis is appropriate, values of four, seven, and ten percent are recommended.

6. Freeway Management Systems (FMS) Deployment Calculations Guideline

6.1 Project Information

The following is a list of the known and assumed information for any given FMS project for evaluation:

Known:

Accident Data (per year):
- Number of fatalities
- Number of accidents with injuries
- Number of accidents resulting in property damage only

Traffic Data:
- Daily VMT
- Daily TMT
- Daily average speed
- Free flow speed (FFS)

Assumptions:

Data:
- All data is expected to increase by 3.5 percent per year for the life of the project.
- Forty percent of annual delay is recurring with incidents.

Project:
- Projects are evaluated as single alternatives.
- A discount factor of seven percent will be used.

6.2 Accident Reduction Benefits

The benefits in accident reduction for an FMS project were identified in Section 5 and are as follows for both urban and rural areas:

- A 15 percent reduction in injury-related accidents and fatalities is anticipated as a result of freeway management services based on data from the FHWA Fatal Accident Reporting System experience in San Antonio. (Urban and Rural)

- A 35 percent reduction in property damage only accidents is anticipated as a result of freeway management services based on data from the FHWA Fatal Accident Reporting System experience in San Antonio. (Urban and Rural)

Calculating the benefit in accident reduction is a three-step process as indicated in the following:

1. Determine the number and type of accidents that occur annually within the project limits;

2. Multiply the number of accidents by the appropriate reduction factor; and

3. Multiply the number of accident reductions by the appropriate accident cost.

Example 6.1: Calculating the Benefit in Accident Reduction – An FMS project is planned for deployment along a section of roadway that has the following accident data for the year 1999: ten fatalities, 250 accidents with injuries, and 250 accidents resulting in property damage only.

Step 1) Determine the number and type of accidents that occur annually within the project limits:

- 10 fatalities
- 250 accidents with injuries
- 500 accidents resulting in property damage only

Step 2) Multiply the number of accidents by the appropriate reduction factor:

- 10 fatalities*15 percent = 1.5 or 2.0 fatalities reduction
- 250 injuries*15 percent = 37.5 or 38 injuries reduction
- 500 property*35 percent = 175 property damage reduction

Step 3) Multiply the number of accident reductions by the appropriate accident cost:

- 2.0 fatalities reduction*$1,000,000 = $2,000,000 benefit in fatality reduction
- 38 injuries reduction*$25,000 = $950,000 benefit in injury reduction
- 175 property damage reduction*$2,500 = $437,500 benefit in property reduction

Total benefit in accident reduction for this FMS project: $3,387,500

6.3 Reduction in Delay Benefits

The benefits in delay reduction for an FMS project in an urban area that has recurring delays were identified in Section 5 and are as follows:

- A 15 percent decrease in delay is anticipated as a result of the deployment of IMS based on data provided by the Maryland CHART Program. (Urban)

Calculating the delay reduction benefits is more complex than calculating the accident reduction benefits; however, it is a relatively easy process. The following two equations were used to calculate the daily delay "cost" for a given project's limits:

$$DailyPassengerVehicleDelay = \$5.78 * (D - TMT - D - VMT)\frac{1}{ADS} - \frac{1}{FFSP}]$$

$$DailyTruckDelay = \$60(-TMT)[\frac{1}{ADS} - \frac{1}{FFSP}]$$

The following text details the calculation of delay reduction benefits:

1. Determine the following from FDOT's MPM Database for a given project:
   - Daily VMT
   - Daily TMT
   - Daily average speed
   - FFS

2. Calculate the daily passenger vehicles-miles traveled (PVMT) by subtracting the daily TMT from the daily VMT.

3. Calculate the affect of change in speed (or the speed factor) by subtracting the difference of the inverses of the daily average speed and the FFS.

4. Calculate the daily average delay cost for passenger vehicles by multiplying the PVMT by the speed factor and then multiply the value by $5.78 per hour for passenger vehicles.

5. Calculate the daily average delay cost for commercial vehicles by dividing the daily TMT by the speed factor and then multiply the value by $60 per hour for commercial vehicles.

6. Calculate the total daily average delay cost by summing the daily average delay cost for both passenger vehicles and commercial vehicles.

7. Calculate the annual delay cost by multiplying the total daily delay cost by the number of working days per year (300).

8. Calculate the annual delay with incidents cost by dividing the annual delay cost by forty percent.

9. Determine the reduction in delay benefit by multiplying the annual delay with incidents cost by 15 percent.

Example 6.2: Calculating the Benefit in Delay Reduction – An FMS project is planned for deployment along a section of roadway that has the following traffic data obtained from the MPM Database:

Step 1) Determine the following from the MPM Database:

- Daily VMT = 3,000 miles
- Daily TMT = 450 miles
- Daily Average Speed = 62 mph
- FFS = 70 mph

Step 2) Calculate the daily PVMT by subtracting the daily TMT from the daily VMT.

3,000 miles – 450 miles = 2,550 miles

Step 3) Calculate the speed factor by subtracting the inverses of the Daily Average Speed and the FFS.

$$\frac{1}{60} - \frac{1}{70} = .002$$

Step 4) Calculate the daily average delay cost for passenger vehicles by dividing the PVMT by the change in speed and then multiply the value by \$5.78 per hour for passenger vehicles.

$$(2{,}550 miles / .002 mph) * \$5.78 = \$7.4 x 10^5$$

Step 5) Calculate the daily average delay cost for commercial vehicles by dividing the daily TMT by the change in speed and then multiply the value by \$60 per hour for commercial vehicles.

$$(450 miles / .002 mph) * \$60 = \$13.5 x 10^5$$

Step 6) Calculate the total daily average delay cost by summing the daily average delay cost for both passenger vehicles and commercial vehicles.

$$\$7.4 x 10^5 + \$13.5 x 10^5 = \$142.4 x 10^5 or \$14{,}240{,}000$$

Step 7) Calculate the annual delay cost with incidents (vehicle-hours) by multiplying the total daily delay cost by the number of working days per year (300) and dividing by 40 percent.

$$(\$14{,}240{,}000 x 300)\$.40 = \$10680 x 10^6 or \$10{,}680{,}000{,}000$$

Step 8) Calculate the benefit in delay reduction by multiplying the annual delay with incidents by five percent.

$$\$10{,}680{,}000{,}000\, x\, .15 = \$1{,}602{,}000\, \textit{benefit in delay reduction}$$

6.4 ATIS Deployment Benefits

There is relatively little information regarding the benefits of ATIS deployments, therefore the following assumptions were made: ATIS will have a 1.5 to 1 benefit to cost ratio. These benefits will be realized in improved travel flow and reduced vehicle delay and miles of travel.

6.5 CVO Deployment Benefits

There is relatively little information regarding the benefits of CVO deployments, therefore the following assumptions were made: CVO will have a 7.0 to one benefit to cost ratio. These benefits will be realized in improved CVO and reduced commercial vehicle delay and miles of travel.

7. Net Present Value (NPV) Calculations

After the benefits are determined, a series of NPV calculations were made for each benefit area. These calculations are outlined in the following sections.

7.1 NPV of the Benefit in Accident Reduction

After the benefit for each type of accident reduction is calculated, they must be projected over the life of the project (ten years). This projection was made assuming a growth rate of 3.5 percent per year.

The following steps illustrate the calculation of the NPV of a benefit in accident reduction:

1) Sum the benefit in reduction from each accident type:

   - Benefit of reduction in fatalities;
   - Benefit of reduction in accidents with injuries; and
   - Benefit of reduction in accidents resulting in property damage only.

2) Project the sum of accident reduction benefits over the life of the project (ten years) using 3.5 percent growth per year.

3) Calculate the NPV of each of the cash flows (benefits) using the following equation:

$$NPV = \sum_{i=1}^{n} \frac{cashflow_i}{(1 + DiscountFactor)^i}$$

Where *i* equals the number of years from the base year up to ten.

Example 8.1: Calculating the NPV of Accident Reduction Benefits – An FMS project is planned for deployment along a section of roadway that has the following accident reduction information: \$2,000,000 benefit in fatality reduction; \$950,000 benefit in injury reduction; and \$437,500 benefit in reduction of accidents resulting in property damage only.

Step 1) Sum the benefit in reduction from each accident type:

- Benefit of reduction in fatalities = \$2,000,000
- Benefit of reduction in accidents with injuries = \$950,000
- Benefit of reduction in accidents resulting in property damage only = \$437,500

Total Benefit in Accident Reduction: \$3,387,500

Step 2) Project the sum of accident reduction benefits (cash flows) over the life of the project (ten years) using 3.5 percent growth per year.

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
$3,387,500	$3,506,063	$3,628,775	$3,755,782	$3,887,234	$4,023,287	$4,164,102	$4,309,846	$4,460,691	$4,616,815	$4,778,403	$4,945,647	$5,118,745

Step 3) Calculate the NPV of each of the cash flows (benefits) using the following equation.

$$NPV = \sum_{i=1}^{n} \frac{cashflow_i}{(1 + DiscountFactor)^i} = \$32{,}485{,}123.57$$

7.2 NPV of the Benefit in Delay Reduction

After the benefit for delay reduction has been calculated, it must be projected over the life of the project (ten years). This projection was made assuming a growth rate of 3.5 percent per year.

The following steps walk through the calculation of the NPV of the benefit in delay reduction:

Step 1) Project the delay reduction benefits over the life of the project (ten years) using 3.5 percent growth per year.

Step 2) Calculate the NPV of each of the cash flows (benefits) using the following equation:

$$NPV = \sum_{i=1}^{n} \frac{cashflow_i}{(1 + DiscountFactor)^i}$$

Where *i* equals the number of years from the base year up to ten.

Example 8.2: Calculating the NPV of Accident Reduction Benefits – An FMS project is planned for deployment along a section of roadway that has the following benefit in delay reduction: $94,762,500 benefit in delay reduction.

Step 1) Project the delay reduction benefits (cash flows) over the life of the project (10 years) using 3.5 percent growth per year.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
$105,064,878	$108,742,148	$112,548,124	$116,487,308	$120,564,364	$124,784,116	$129,151,560	$133,671,865	$138,350,380	$143,192,644

Step 2) Calculate the NPV of each of the cash flows (benefits) using the following equation.

$$NPV = \sum_{i=1}^{n} \frac{cashflow_i}{(1 + DiscountFactor)^i} = \$908{,}744{,}360.78$$

8. Benefit to Cost Ratios

Once benefits and their NPV have been calculated, a comparison of the benefits to the project's cost must be made. This is called a benefit to cost ratio. The following equation will be used to calculate the benefit to cost ratio:

$$\frac{Benefits}{Costs} = \frac{TotalNPVUserBenefits}{TotalNPVOwnershipCosts}$$

Where *NPV* equals Net Present Value.

ITS projects with a benefit to cost ratio greater than one are considered economically feasible for deployment, while ITS projects with a benefit to cost ratio of from 0 to 1 should not be recommended when evaluated from an economic standpoint alone.

Example 9.1: Benefit to Cost Ratio Calculation – An FMS deployment has the following costs and benefits associated with it:

- $630,000,000 in total construction cost (includes PE, CEI, and O&M)
- $32,485,123.57 NPV in benefits from accident reduction
- $908,744,360.78 NPV in benefits from delay reduction

$$\frac{Benefits}{Costs} = \frac{\$941{,}229{,}484.35}{\$630{,}000{,}000.00} = 1.5$$

$$1.5 > 1$$

As indicated above, 1.5 is greater than one, therefore this deployment is feasible and should be recommended for implementation from an economic standpoint.